固定交易成本下的模拟动态资产分配：多阶段随机规划 BayigImandi Aaron William

指导教师蔡立耑助理教授厦门大学

学校编码：10384　　　　　分类号＿＿＿＿＿密级＿＿＿＿＿＿

学　号：27720111154383　　UDC＿＿

厦门大学

硕士学位论文

比例交易成本下的模拟动态资产分配：多阶段随机规划

Simulated Dynamic asset allocation in the presence of proportional transactions Cost: multi-stage stochastic programming

Bayig Imandi Aaron William

指导教师姓名：蔡立耑助理教授

专业名称：金　融　工　程

论文提交日期：2013 年 09 月

论文答辩日期：2013 年 11 月

学位授予日期：2 0 1 3　年　月

答辩委员会主席：＿＿＿＿＿＿

评阅　人：＿＿＿＿＿＿

2013 年 12 月

厦门大学学位论文原创性声明

本人呈交的学位论文是本人在导师指导下,独立完成的研究成果。本人在论文写作中参考其他个人或集体已经发表的研究成果，均在文中以适当方式明确标明，并符合法律规范和《厦门大学研究生学术活动规范（试行）》。

另外，该学位论文为（）课题

（组）的研究成果，获得（　　　　）课题（组）经费或

实验室的资助，在（）实验室完成。（请在以上

括号内填写课题或课题组负责人或实验室名称，未有此项声明内容的，可以不作特别声明。）

声明人（签名）：

Bayig Imandi Aaron William

年　月　日

厦门大学学位论文著作权使用声明

本人同意厦门大学根据《中华人民共和国学位条例暂行实施办法》等规定保留和使用此学位论文，并向主管部门或其指定机构送交学位论文（包括纸质版和电子版），允许学位论文进入厦门大学图书馆及其数据库被查阅、借阅。本人同意厦门大学将学位论文加入全国博士、硕士学位论文共建单位数据库进行检索，将学位论文的标题和摘要汇编出版，采用影印、缩印或者其它方式合理复制学位论文。

本学位论文属于：

（）1.经厦门大学保密委员会审查核定的保密学位论文，于　年　月　日解密，解密后适用上述授权。

（√）2.不保密，适用上述授权。

（请在以上相应括号内打“√”或填上相应内容。保密学位论文应是已经厦门大学保密委员会审定过的学位论文，未经厦门大学保密委员会审定的学位论文均为公开学位论文。此声明栏不填写的，默认为公开学位论文，均适用上述授权。）

声明人（签名）：

Bayig Imandi Aaron William

年　月　日

摘要

本文旨在研究模拟环境下的动态资产分配系统，例如，一个风险厌恶的投资者在选择收益互相依赖的不同资产时面临交易成本。这个动态资产分配系统可以帮助该投资者在短期内实现预期效用最大化。该系统建立在一个用多阶段随机规划来处理市场不确定性的实践模型基础上。这个模型稍微偏离了大多数有关资产分配论文的数学复杂性，而是利用一个能够很好描述市场的简单模型来表现交易成本。为了证明它的有效性，我用 GAMS 设立一个小的应用来提升它。我通过改变交易成本、风险意识、时间长度和目标在模拟环境中进行了 4 次独立的实验操作。所有的实验结果表明交易成本和实际环境中是一样的。我将我的研究结果和其他有不同假设环境的学术研究结果进行了比较，他们很好的与主流理论与学术直觉契合。我的模型很好地反应了现实并具有实际意义。我的研究结果进行了稳健检验，证实了其有限性并且可以成为一种可靠的工具。

关键词： 动态资产分配　 随机规划　交易成本 GAMS

Abstract

In this work, the researcher aims at creating a system for dynamically allocating assets in a simulated environment where for example a risk adverse investor faces transaction cost with asset dependent returns. This system helps the investor to maximize his expected utility over a particular time frame. The system is based on a practical model which uses an innovative version of the three stages stochastic programming to cope with uncertainty of the market. This model deviates from the mathematical standard on the topic of asset allocation in business transactions, but reaches to the same result and justifies the intuition of practitioners. The system captures the reality of the market transactions. To prove its power, the researcher has created a small application to implement the three stages stochastic model using GAMS and the researcher has connected four independent exercises by changing the transaction cost, risk alertness, length of time used and goals in a dynamic simulated environment. In all the exercises the transaction costs are presented as it is in the real market. The results will then be compared with those from other academic works that have used different settings. They are in line with major theories and other practical applications. This model captures very well the reality of market transactions and also has a practical application. The results are tested for robustness. This system based on an innovative three staged stochastic programming works and turns to be a reliable tool to the investor.

Key Words: Dynamic asset allocation, stochastic programming, transaction cost, GAMS

Acknowledgement

This Research paper is possible because of the support of many people. I wish to express gratitude to my family and my supervisor, Prof. Tsai Li-Chuan Who was very helpful and offer invaluable comments, assistance and guidance.

Contents

Motivation

Academics build mathematical models based on many assumptions. Some of these models cannot be applied and might fail to explain reality because of the unrealistic assumption such as efficient market hypothesis, the lack of transaction cost, and the existence of only one risky asset with risky free asset and so on. With these strict assumptions, models may mislead the investor. This justifies the reaction of the practitioner who prefers to go by unjustified intuition and experience. This creates a gap between the technicians and the fundamentalists. The aim of this research work is to break the gap between the practitioner and the academics. I propose a practical system with a model which captures both the reality of the market and justify the intuition of the experienced practitioner. The system is to be implemented in GAMS language using a very little computational power. This system is to request from the user at running time the transaction cost, the length of the investment and the target to be reached which is fed into the three stages of stochastic version of the model giving visible results. The researcher has tested the results generated from our model which are in line with the conclusion of existing theory. With a very little computational power, the researcher is able to generate almost instantly a different asset allocation for different market conditions and investor preferences. The researcher has provided the individual investor with the model based on the three stages of stochastic transactions. It assists the investor in his/her investment in the dynamic market.

Chapter I Introduction

The progress made in computational power and the readily available information on the right format has helped the growth of the number of traders and investors. However the computation power is just a tool, in order to be successful, the investor must rely on the quality of his model to capture the reality of the market. He uses the computer only as a device of fast implementation. Asset allocation is one of the main types of investment in the financial market. This research work will attempt to introduce a new system with a practical model for asset allocation in a dynamic market. The system will include a multi stage stochastic based model dealing with the market in presence of transaction cost and asset dependent return.

The growing interest in investment has led to the need for customized investment strategies. They assume the market to be efficient and willing to invest into index funds or other financial instruments. This required less effort from the investor as he trusts the prices listed on the market. The second type of investor is the active trader. Here, the investor does not completely rely on the market but on his strategy, he does the analysis of the performance and the valuation of financial instruments considered for investment and based on his result and his investment requirement. He then designs a portfolio which meets his needs.

Asset allocation or portfolio construction is a major decision for an investor. It aims to balance risk and reward by apportioning assets to a portfolio according to the individual's goals, risk tolerance and investment horizon. The major classes of assets are stocks, bonds and cash. Each one of them is influenced differently by the market factors. In practice these classes of assets are subdivided into subclasses. The selection of an individual instrument is a low level decision with a small impact on the portfolio performance. For these reasons when assigning weights to asset classes one should consider all possible financial aspects and choose only among the main class of assets. This is respected in the model the researcher developed in this research work.

In a paper *Portfolio selection* published in 1952, Harry Markowitz developed procedure for static portfolio optimization. This is considered as the backbone of modern portfolio theory. This static framework failed to capture some aspects of uncertainty but has made our understanding of the market better. The major drawbacks of the Markowitz model are the use of variance as a measure of risk, the lack of adjustment to a changing market and the ignorance of the third and the fourth moments. The limitations of the static model have been studied by academics to create better theoretical models.

Dynamic portfolio choice was introduced by Merton R.C(1969). He observed the changing means and variances over time to respond to the change in economic conditions. The investment strategies should be designed to protect against these fluctuations and if possible take advantage of them. Dynamic asset selection can be seen as a financial optimization problem under uncertainty. Here the investor wants to maximize his return or expected utility for a given risk and or minimize the risk for a given return.

In real life an investor's goals, constraints and preferences are subject to change due to the release of new information. So it is very less likely for an investor to maintain the same mix of assets for the whole time horizon regardless of the change in the market conditions. For these reasons dynamic models fit the practical cases of optimal investment. The time horizon is usually divided in periods. At the end of each period the mix of assets is evaluated to see if it fits the preferences and the constraints of the investor and the market's condition if not reallocation of asset happens. To capture the risk tolerance and the satisfaction of the investor, we need to consider his current wealth, future wealth, financial goals, and some of the other preferences. This is well modeled by a utility function. The risk tolerance of an investor can be categorized as risk lover, risk neutral or risk averse. And the created system takes into account the investor preferences, the market condition and the investor risk alertness.

This research work describes and constructs a system to build dynamic portfolio for an individual investor in the presence of transaction cost and serially dependent financial instrument return. In dynamic asset allocation with uncertainty, we have few model options available to us. We have dynamic stochastic programming and multi stage stochastic programming to name a few. It is preferable to choose and innovate the multi-stage stochastic programming over the dynamic stochastic programming due to the presence of transaction cost and serially dependent return to help the researcher's model deal with uncertainty.

This research will be organized as follows: chapter two will review some important publications and literature on the area of dynamic asset allocation and portfolio selection for the model. Chapter three describes the methodology, some important concepts and set the model to be used in the last section. In chapter four, the researcher will implement our system in a simulated environment and analyze the result. The last chapter is the conclusion.

Chapter II Literature

The growth investment opportunities have given room to the need for customized investment system. Some of the investment systems are based on strong mathematic model which cannot capture the market or justify the intuition. Here we propose to the investor with reliable tool. This part will elaborate the evolution of the model of our system.

Financial allocation of scares resources are generally optimization problems. It can be about minimizing risk or maximizing utility or return for a given level of risk. The financial market is the scene of interaction for many economic factors such as inflation, unemployment rate and asymmetric information. Their interaction creates uncertainty and prevents us from predicting the return of financial instrument such as stocks or bonds. Due to the dynamic aspect of the market we required dynamic model which will cope with the presence of uncertainty. Under the strategic asset allocation, individual investor or enterprise have specific target .They use dynamic asset allocation to adjust the mixed asset in order to meet the investment goal, the implementation of this method can be found in Blake et al. (1999). However, dynamic asset allocation can be used to take advantage of the market. This strategy is known as tactical asset allocation. Here the portfolio manager may have a fixed target but be willing to deviate from it to take advantage of the market and make some extra profit.

When considering an investment valuation is an important factor and it is commonly done using a utility function Mossin J. (1968) works on optimal multi-period investment with objective maximization of expected utility. He values the wealth of the investor at the end of every myopic period with utility function to see if any re-mix is necessary. He noticed that in a multi-period investment problem, the investor must consider and optimize only the current period as its return is independent of what has come before and what will be next. In addition he observed that asset with serially independent return (are well valued by power utility function) and those with general return distribution such as normal distribution (are well valued by logarithmic utility function) are completely myopic. In opposition to Mossin J. (1968), Hakansson N.H (1971) notices that with Hyperbolic absolute risk aversion (HARA) there is no optimal myopic strategy except under unrealistic scenario such as absence of borrowing and sure teeing. To convert a multi-period investment into a multi-myopic investment, there must be a correspondence between the distribution of asset return and the utility function used to value the investment at the end of the period. For example HARA utility function proved to work well with serial dependent return asset. It can be considered for serial independent asset returns only in absence of borrow and sure teeing which is not realistic. The power utility function dwells well with serially independent asset return. In a broad manner the logarithm utility function works well for both dependent and independent asset return. However with the growth in computer power and progress made in stochastic programming algorithm, it is easy to financially optimize investment problem with various combinations of different types of utility function and asset return distribution.

The existence of market friction such as transaction cost tends to influence investment decisions. We can distinguish two types of transaction costs: fixed transaction cost and proportional transaction. Proportional transactions are representative of the amount invested into the risky assets in contrast to the fixed which are independent of the amount. Zakamouline V.I (2002) studies the optimal portfolio of an investor facing both fixed cost and proportional cost in a continuous environment. In his result he found that the existence of transaction cost causes the existence of three distinct portfolio regions namely: the buy, the sell and the non-transaction region. In the buy region risky assets are bought until target is reached in contrast to the sell region where they are sold. Before him Constantinides G.M (1986) and Davis M.H.A., and A.R. Norman (1990) show the existence of a non-tradable interval for a multi period risky investment in continuous time. But Lui J. (2004) was the first to provide analytical characteristics of the no trade region for an investment in multi risky asset with independent return. Despite this intensive work on the relation between transaction cost and asset allocation. A clear answer is yet to be found.

One of the key decisions in investment is the duration of the investment namely the time frame. The length of the time does influence the composition of the portfolio. Siegel J. (2002) notices that in long run the stock grows faster than fixed return assets but in short period of time the profit accumulated can turn into loss due to higher risk. The existence of low risk in fixed return financial instrument makes them ideal for short run investment. The right combination of stock and bond is subject to the change of time horizon. Gunthorpe D. and Levy, H (1994) studies the relationship with time against the portfolio allocation and performance and they found that it is correlated. Gerd I. (2003) notices that “Practitioners tend to recommend a larger allocation towards stocks as the investment period increases. This is often argued under the name of “time diversification”. This is based on the argument that if stocks are distributed independently and identically in each time period according to a log normal distribution, the distribution over many periods as the product of log normal is also log normal and the mean and the variance of the logarithm of the return distribution grows proportionately with the length of the investment period.”In opposition with the practitioners Samuelson P.(1969) with a recurrence backward dynamic programming proved that the distribution return of risky asset is independent and identical for every period. With respect to consumption and the expected utility, the investor is advised to invest the same amount of wealth into stock at every period unrelated to his wealth. In the same line Merton R.C (1969) elaborated the same theory but this time for continuous cases. The time frame seems to be function of many others factors such as the ability to generate periodic income, personal wealth and liability.

To dynamically allocate asset, two powerful stochastic algorithms can be used: stochastic programming and stochastic control. They proved practical success and efficiency at allocating asset while considering various utility functions, length of time, investor preferences, market uncertainty and any change made on them throughout the investment period. Despite being closed in principle, these two methods present different features.

Stochastic control or stochastic dynamic programming is an extension of Bellman R. (1957) dynamic programming principles. This method is compatible with the HARA type of utility function and less with the others. For the general looking utility function, monotonic increasing and concave there is not clear solution. One of the drawbacks of the original model is the limited size of state variables. It is meant to be between 1 and 4 states variable to avoid complexity and guaranty solvability. However De Farias D.P. and Van Roy B (2003), presented an extended version of the model which supports large number of state variables but the efficiency and accuracy of this new version of the method is yet to be proved to academic and practitioner. Dynamic Stochastic programming is an efficient way to find optimal allocation of asset provided that the transactions costs are excluded and the asset returns are serially independent. The exclusion of transaction costs alone makes this method less realistic and unable